SCIENCE DIPLOMACY REVIEW

Vol. 1 | No. 2 | March 2019

(Continued on outside back cover)

SCIENCE DIPLOMACY REVIEW

Vol. 1 | No. 2 | March 2019

SCIENCE DIPLOMACY REVIEW

Vol. 1 | No. 2 | March 2019

EDITORIAL

Science Diplomacy Review (SDR), brings forth contributions from a wide range of stakeholders on topics related to Science Diplomacy and stimulate research in this field. It delves with perspectives and concerns of the global South, in the arena of Science Policy, Science Diplomacy and STI Cooperation. The second issue of SDR focuses on global and national S&T discourses, related to climate change, migration, international cooperation and inclusive growth.

The first article authored by Bhaskar Balakrishnan on '*Climate Change, Paris Agreement and Global Action: A Way Forward*', elucidates on the latest developments in the global diplomatic efforts to tackle climate change at the Katowice Climate Conference in Poland. It highlighted the element of hope amid developing countries, despite disappointing outcomes of the conference. The article reflects on some of the actionable agenda including increased pressure by civil society and the scientific community, need to improve science in the areas of global climate models, solar energy capture and storage as well as in carbon capture and sequestration technology, thereby providing escape hatches from the doomsday scenario of climate change.

The second article, '*Science Diplomacy and Cooperation in Science and Technology in India*' by Jyoti Sharma and Sanjeev Kumar Varshney, provides a comprehensive review of India's bilateral science and technology agreements and programmes of cooperation undertaken by the Department of Science and Technology of the Government of India. An interesting read to understand scope and diversity of STI cooperation undertaken by the department, which highlights various actors and institutions at national and international levels.

'*Brain Drain and Brain Circulation: Why Collaboration matters?*', written by Nimita Pandey, discusses India's trajectory from witnessing 'Brain drain' to 'Brain Circulation', in the light of movement of Indian scientists from US to their home countries. This shift in terminology is significant, and reflects the increasing capacity of the S and T ecosystem in the developing world to attract the participation of expatriate S & T professionals. However, the article highlights challenges and issues in collaborating for these scientists with foreign counterparts, despite being educated in their countries.

The issue also comprises of a note on the Pathways Commission's report on Technology Management and Inclusive Growth, setting a reminder that technology besides being disruptive can accentuate inequalities. The News update section covers some interesting recent developments in Science & Technology, Science Policy and Science Diplomacy.

The *Science Diplomacy Review* hopes to attract a wide range of contributions from the field of Science Diplomacy across the globe, including stakeholders. We look forward to benefit from comments of our readers.

ARTICLE

Climate Change, Paris Agreement and Global Action: A Way Forward

Bhaskar Balakrishnan*

BHASKAR BALAKRISHNAN

The recent Climate Change Conference at Katowice, Poland, in December 2018 has been seen by many as leading to a minimal outcome in dealing with Climate Change. Faced with mounting scientific evidence and increasingly serious assessment of threats arising from global warming, the Conference barely could reach agreement even after extended sessions on the rule book for implementation of the Paris Agreement; this rule book has fallen far short of the expectations of many stakeholders. Important issues such as voluntary trading could not be covered owing to disagreements among member states.

Towards Tipping Point?

Meanwhile, the latest annual estimates of global emissions from the Global Carbon Project (GCP) have found that output from fossil fuels and industry would grow around 2.7% in 2018, the fastest increase in seven years (Carbon Brief, 2018a). The magnitude of the challenges can be gauged from the fact that global warming (average increase in Earth temperature since the pre industrial revolution base) has reached 1.17 degree Celsius. The latest IPCC report had warned of the grave consequences if the warming exceeded 1.5 degrees. When the Paris agreement was negotiated, the limit for global warming was set at 2 degree C, and total carbon dioxide equivalent levels in the atmosphere were to be kept below 450 parts per million volume (ppmv). The data of January 2019

* Science Diplomacy Fellow, RIS and Former Ambassador of India. He holds a PhD in Theoretical and Mathematical Physics from State University of New York, Stony Brook.

indicate that CO_2 level has already reached 413.9 ppmv; with an average rate of increase of 2.24 ppmv per year. At this rate, the "tipping point" of 450 ppmv would be reached by March 2035. Of concern is the sharp rise in methane (which has high global warming potential) to 1850 parts per billion (ppbv); growing at 6 per cent per year.

To stay within the limit of 1.5 degree, a sharp cut in greenhouse gas emissions or technology to remove greenhouse gases from the atmosphere would be essential. Relief can be provided if technology for removal of CO_2 either from the atmosphere or from the industries such as cement, power, petroleum and steel is applied.

Montreal Protocol and Climate Change

There was an unexpected slowdown in the reduction of CFC11 level, used in refrigeration and cooling industry, which has been phased out since 2004 under the Montreal Protocol. This has been traced to increased emissions of CFC-11 in eastern Asia by certain Chinese entities, mislabeling banned Chlorofluorocarbons (CFCs) as hydrochlorofluorocarbons (HCFCs). China has acknowledged this, and has pledged to take corrective action (Venkatesh, 2018)

Under the Montreal Protocol to save Ozone layer, CFCs and HCFCs called Ozone Depleting Substances (ODS) were to be phased out. They were replaced by HFCs. This resulted in the improvement of ozone layer. However, the very success of the Montreal Protocol increased HFCs levels in the atmosphere with very high global warming potential (150 to 11000 times that of Carbon Dioxide). This required adoption of the Kigali Amendment to the Montreal Protocol (which has been entered into force on 1 January 2019); under which HFCs are to be phased out. The goal is to achieve over 80% reduction in HFCs consumption by 2047. The impact of the amendment would reduce by up to 0.5 °C the increase in global temperature by the end of the century. Technically, this means that alternative technology, including use of refrigerant gases such as Ammonia, Hydrocarbons, Carbon Dioxide etc., would need to be used in refrigeration and air conditioning equipment. This would require management of problems of toxicity, flammability and lower system energy efficiency. This presents a technological challenge.

Increase in Warming of Oceans

Another study based on more accurate data on ocean temperatures measured directly through the Argo network of floating sensors has indicated that the oceans are warming much faster than was estimated using the earlier data (Cheng *et al.*, 2019); which were based on the indirect measurements and estimates. The oceans are the major reservoir of heat energy (over 90 per cent) in the global climate system, and are linked to circulation of water vapour in the atmosphere. The next IPCC report is expected to address this issue. Water vapour, present in the atmosphere, is a potent greenhouse gas, but owing to its rapid changes and ability to transform into clouds and rain, its global warming effects so far have not been quantified. Some experts, however, have warned of a possible feedback effect of water vapour amplifying global warming. Even the global cooling effect of clouds and aerosols has not been studied sufficiently. All this indicates for the need for greater effort in global climate modeling to improve calculation of the effects of greenhouse gas emission levels, and to predict extreme climate events in time and location. The ability to do the latter would be highly beneficial for adaptation efforts.

The Need for More R&D in CCS technology

Much greater R & D efforts need to be made in the area of Carbon Capture and Sequestration (CCS)[1] technology and negative emission technologies (including direct air capture and sequestration). At present, natural CCS is being used mainly through planting of additional forest and green areas (Ni *et al.*, 2016). Breakthroughs in this would provide valuable carbon space and enable developing countries to meet needs of economic development. It would also reduce the pain of developed countries in meeting their emission reduction commitments. R & D efforts for CCS should especially be targeted on concentrated sources such as cement production, while continuing efforts in steel, power, and hydrocarbon processing sectors. Introduction of a realistic carbon pricing mechanism, for example, a carbon tax, may lead to an economic boost for these technologies. However it must be emphasized that CCS is not to be seen as a mere "technical fix" to the problem of emission reduction, but as a complement to vigorous efforts to move away to lower emission technologies.

Divisions Sharpen at COP24

The extent of the divide among member states could be judged from differences over the language regarding the IPCC report on 1.5 degree warming. As at IPCC 48, the pro-fossil fuel countries lobbied hard to dilute the importance of the report and refused to "welcome" the latest IPCC report (Carbon Brief, 2018b), insisting instead only to "note" it. The final text did not "welcome" the report, but did welcome its "timely completion" and "invited" countries to make use of the report in subsequent discussions at the United Nations Framework Convention on Climate Change (UNFCCC).

The most technical and challenging area of negotiations was on the rules for voluntary market mechanisms under Article 6 of the Paris agreement. This includes Article 6.2, under which countries can trade over achievement of their climate pledges, as well as Article 6.4, under which individual projects can generate carbon credits for sale. In the end, the whole section was deferred to COP25 to be in November 2019. The most contentious point was on basic accounting rules to prevent "double counting" of emissions reduction by the buyer and the seller of offsets, as well as on credits for legacy emission reductions prior to the Paris Agreement.

In other areas, there was a visible weakening of provisions relating to emissions accounting, climate finance reporting, and on transparency and flexibility. One potentially important detail commits countries to report emissions in "CO_2 equivalents", using Global Warming Potentials[2] over 100 years. The differentiated regime for developing and developed countries was further diluted. A global stocktaking process has been agreed and the first such one would be in 2023. COP24 has agreed to set up an expert compliance committee that is "facilitative in nature…non-adversarial and non-punitive" (UNFCCC, 2015).

Countries are set to re-submit or update their climate pledges (known as "nationally determined contributions", or NDCs) in 2020. The Paris Agreement would come into effect in 2020, but countries had agreed in 2015 to take stock in 2018 of the progress on the climate action to date. This Talanoa dialogue began in January 2018, and concluded in a political phase during the second week at Katowice. The Paris Agreement says that successive pledges should "represent a progression" on the previous one – and "reflect its highest possible ambition", while also acknowledging different national circumstances. Going by the present trends, the total of all NDCs is likely to be far short of what is needed to keep global warming below 1.5 degree C

Progress Made at COP 24

During the COP, several countries including India, Canada, Ukraine and Jamaica, indicated willingness to submit increased climate pledges in 2020. Several dozen countries from the "High Ambition Coalition" – including the EU, UK, Germany, France, Argentina, Mexico and Canada – pledged to step -up their ambition by 2020. This would be done through enhanced climate pledges, low-emission development strategies and increased short-term action. The special efforts, made by large developing countries, such as India, China, Brazil, and South Africa, in the face of withdrawal of a few large advanced countries from the Paris Agreement deserve high praise.

On the setting of a new climate finance goal, the Paris Agreement says this should be set by 2025 and should go above the $100bn per year "floor" promised to developing countries by 2020. The COP 24 parties had agreed to start discussing this new goal at COP26 in November 2020. Meanwhile, rich countries' contributions remain well short of the $100bn target for 2020. Several announcements at the COP showed some scaling-up of finance for the Adaptation Fund; raising the total pledges to $129m – a record annual fund-raising. Germany also became the first country to announce a concrete amount for the Green Climate Fund (GCF)'s replenishment round, offering €1.5bn —double the amount of the previous contribution in 2014. Norway pledged $516m to the GCF, while Japan would consider more funding once the replenishment process officially starts in 2019. The GCF has so far received only $7bn of the $10bn promised to it in 2014 due to US backing out of its $3bn pledge as well as change in exchange rate for the US dollar.

The World Bank has announced $200bn for its 2021-2025 climate investment programme, which doubles the $100bn; given during previous five-year investment plan up to 2020. Half the total would come directly from the Bank, with equal shares of this going to mitigation and adaptation. The remaining $100bn will come from other parts of the World Bank group and "mobilised" private capital, the Bank said. The World Bank was also one of nine multilateral development banks who made a declaration at the COP to "align… their activities" with the goals of the Paris Agreement. Also, a combined loan book of €2.4tn has been committed by five Banks, namely Standard Chartered, ING, BNP Paribas, BBVA and Société Générale, in order to measure the climate alignment of their lending portfolios, to navigate them towards "well below 2C" target (Climate Diplomacy, 2018).

Climate-Induced Migration

There is increasing recognition internationally about how climate change may affect migration of people; both within their own country and to different ones. The World Bank recently mentioned that up to 143 million people in Sub-Saharan Africa, South Asia and Latin America can be forced to migrate internally by 2050 due to climate change. The Warsaw International Mechanism (WIM), the formal mechanism, for addressing the loss and damage caused by climate change adopted a final text, which "invites" countries to consider recommendations of a task force set up by the Paris agreement, which touch on many issues related to both internal and cross-border migration. The WIM also decided to extend the mandate of the Task force – for exactly how long is yet to be decided.

The "Just Transition" Issue

A new issue was injected into the climate deliberations on the adverse impact on employment of energy transition away from fossil fuels. Some 50 countries have adopted a separate "Silesia declaration", which emphasize the need for emission-reducing policies to ensure "a just transition of the workforce" that creates "decent work and quality jobs". Earlier, in 2016, the ILO had developed guidelines on the concept of a "just transition" during the achievement of sustainable development goals. The presence of a large coal mining industry in Poland no doubt influenced this. If fossil fuel use is to continue, especially in power plants and steel production, the obvious solution is to use Carbon Capture and Sequestration (CCS) technology which enables Carbon Dioxide to be removed from emissions of plants and stored. This may cut down global warming impact of such industries. The other track is to use coal, oil and gas for transformation into other useful chemical products rather than for producing energy. In addition, technology for Direct Air Capture (DAC) of Carbon Dioxide is advancing, which would remove Carbon Dioxide from the air and convert it into useful fuel and chemicals.

The Next Steps – Global Climate Summit

A key event in 2019 would be a UN climate summit set to take place in September in New York. This is seen as a place where more stringent pledges may be announced. COP 25 is due to take place from 11-22 November 2019 in Chile, with Costa-Rica hosting the "pre-COP". The UK and Italy have both indicated their interest in hosting COP26 in 2020. This is considered a crucial COP as it is when countries have been asked to submit their next round of climate pledges for 2030. All countries need to prepare well for discussions. And holding wide ranging national stakeholders' consultations would be essential to enlist support of civil society.

Role of Science Diplomacy

Climate change is perhaps the defining challenge of the 21st century. It presents a conjunction of formidable challenges of multidisciplinary nature to scientists, policy makers, and civil society across the globe. Facing this challenge requires science diplomacy of a high order, where scientists must do more research about the science underlying climate change phenomena.

In turn, they must inform non-scientists including policy makers and civil society in clearly comprehensible terms about the scientific knowledge underlying climate change phenomena. Close cooperation between climate scientists and policy makers and civil society stakeholders is necessary for international negotiations to work. It is possible that new approaches to global governance may emerge as a result of climate change negotiations, especially the role of sub-national entities and transnational coalitions. The temptation to hammer out agreements behind closed doors and push them through should be avoided. Transparency in the negotiation process is important for success, as agreements must receive the widest possible support and cooperation to be effective.

A Strategy for Survival

Clearly a survival strategy for mankind in dealing with climate change should be based on (1) Continuing and widespread efforts to reduce greenhouse gas emissions, (2) Outreach to sub-national entities and private sector, especially of countries that have withdrawn from the Paris Agreement to adhere to the spirit of and implementation of the Paris Agreement objectives, (3) Massive global R & D effort to achieve breakthroughs in CCS technologies, (4) Massive R & D effort to evolve much more precise global climate models and predict extreme climate events, and (5) Intensify the current R & D efforts to achieve breakthroughs in solar energy capture and storage systems. There is a need to take up at least three of the "mega science "activities as mentioned above. It is ironic that the scientific community has deployed enormous resources on projects such as ITER and the Large Hadron Collider while making relatively lesser efforts in projects of relevance to climate change.

Integrated Approach to Address Major Global challenges

In another development, an academic group has issued a report on the multiple serious and coincident global challenges of the "anthropocene" or human era (Sterner, *et al*, 2019). This has been echoed in the World Economic Forum's Global Risk Report for 2019 (WEF, 2019). This stresses the importance of tackling multiple challenges such as climate change, biodiversity preservation, water, pollution, disease, etc and brings out their mutual inter-linkages. It calls for an integrated approach to managing these multiple challenges stating that "policy design needs to deal with a multitude of geographic levels, interconnected boundaries, and spatial, ecological and socio-political complexities".

Solutions designed to deal only with one global issue may impact on other global issues. This was the case with the Montreal Protocol, which led to HFC use having very high global warming potential. The WEF report (2019) notes that, "…the world is facing a growing number of complex and interconnected challenges—from slowing global growth and persistent economic inequality to climate change, geopolitical tensions and the accelerating pace of the Fourth Industrial Revolution. In isolation, these are daunting challenges; faced simultaneously, we will all struggle if we do not work together". However the divisions among nation states and the trends towards increasing polarization, nationalism and global conflict do not augur well for humanity.

Endnotes

[1] EPA (2019) defines CSS as 'a set of technologies that can greatly reduce CO2 emissions from new and existing coal- and gas-fired power plants and large industrial sources. It is a three-step process that includes (a) Capture of CO2 from power plants or industrial processes; (b) Transport of the captured and compressed CO2 (usually in pipelines); and (c) Underground injection and geologic sequestration (also referred to as storage) of the CO2 into deep underground rock formations.'

[2] The EIA (2019) defines Global Warming Potential (GWP) as 'an index used to compare the relative radiative forcing of different gases without directly calculating the changes in atmospheric concentrations. GWPs are calculated as the ratio of the radiative forcing that would result from the emission of one kilogram of a greenhouse gas to that from the emission of one kilogram of carbon dioxide over a fixed period of time, such as 100 years'.

References

Carbon Brief. 2018a. 'Analysis: Fossil-fuel emissions in 2018 increasing at fastest rate for seven years'. Retrieved on 17 January, 2019 from https://www.carbonbrief.org/analysis-fossil-fuel-emissions-in-2018-increasing-at-fastest-rate-for-seven-years

Carbon Brief. 2018b. 'COP24: Key outcomes agreed at the UN climate talks in Katowice'. Retrieved on 10 January, 2019 from https://www.carbonbrief.org/cop24-key-outcomes-agreed-at-the-un-climate-talks-in-katowice

Cheng, L., Abraham, J., Hausfather, Z. and Trenberth, K.E., 2019. How fast are the oceans warming?. *Science*, *363*(6423), pp.128-129. Retrieved on 29 January, 2019 from http://science.sciencemag.org/content/363/6423/128

EIA. 2019. 'Glossary: Global Warming Potentials (GWP)'. U.S. Energy Information Administration. Retrieved on 21 January 2019 from https://www.eia.gov/tools/glossary/index.php?id=G

EPA. 2017. 'Carbon Dioxide Capture and Sequestration: Overview'. U.S. Environmental Protection Agency. Retrieved on 27 January, 2019 from https://19january2017snapshot.epa.gov/climatechange/carbon-dioxide-capture-and-sequestration-overview_.html

Ni, Y., Eskeland, G.S., Giske, J. and Hansen, J.P., 2016. 'The global potential for carbon capture and storage from forestry'. *Carbon balance and management*, *11*(1), p.3.

Sterner, T. Barbier, E.B and Robinson, A. 2019. 'Policy Design for the Anthropocene', *Nature Sustainability*, vol. 2, pp. 14–21. Retrieved on 22 January, 2019 from https://www.nature.com/articles/s41893-018-0194-x

UNFCCC. 2015. 'Article 11: Facilitating Implementation and Compliance'. Retrieved on 24 January, 2019 from https://unfccc.int/sites/default/files/sog_on_arts11and12to26_input3_23oct2015.pdf

Venkatesh, S. 2018. 'How Chinese foam manufacturers are undermining the Montreal Protocol'. Retrieved on 22 January, 2019 from https://www.downtoearth.org.in/news/environment/how-chinese-foam-manufacturers-are-undermining-the-montreal-protocol-61629

Climate Diplomacy. 2018. COP24: Key outcomes agreed at the UN climate talks in Katowice. Retrieved on 23 January, 2019 from https://www.climate-diplomacy.org/news/cop24-key-outcomes-agreed-un-climate-talks-katowice

WEF. 2019. *The Global Risks Report 2019*. Retrieved on 18 January, 2019 from http://www3.weforum.org/docs/WEF_Global_Risks_Report_2019.pdf

ARTICLE

Science Diplomacy and Cooperation in Science and Technology in India

Jyoti Sharma*

SanjeevKumar Varshney**

JYOTI SHARMA

SANJEEV KUMAR VARSHNEY

Introduction

Science Diplomacy has been identified as a potential tool to strengthen or improve relations among nations, addressing global issues and exchange of resources where Science, Technology and Innovation (STI) has been identified as an engine of the social and economic progress and also a driver of globalization. Science diplomacy also strengthens principles of science and makes it more transparent and powerful. However, this scientific dimension of diplomacy is powerful only if the tools promoting it are effective.

India is an emerging power comprising a large number of scientists with high potential to contribute to future growth of science.. India's foreign policy gives more emphasis on the application of Science & Technology (S&T) for the development of international co-operation, and it has the mandate to identify, facilitate and promote India's international cooperation in frontier and emerging areas of the STI under bilateral, regional and multilateral programmes enabled through the Transaction of Business Rules &the Cabinet Business Rules. A new agreement between Department of Science and Technology (DST), Government of India, with the Third World Academy of

*Senior Scientist, International Bilateral Cooperation Division (IBCD), Department of Science and Technology, Ministry of Science and Technology, Govt. of India. Corresponding author.

**Head & Advisor, International Bilateral Cooperation Division (IBCD), Department of Science and Technology, Ministry of Science and Technology, Govt. of India.

Sciences (TWAS) to provide funding of $1 million over the next five years to support cooperative efforts in science diplomacy training shows India's commitment to promote and support science diplomacy (DST, 2015).

India's involvement in global Big Science projects at the European Organization for Nuclear Research (CERN) in Geneva, the International Thermonuclear Experimental Reactor (ITER) in France, the Laser Interferometer Gravitational-Wave Observatory (LIGO) science collaboration, the International Solar Alliance and its commitment to promote renewable energy and to fulfil targets set in the Paris Climate Agreement have amply demonstrated its global networking capacity and commitment (DST, 2018)

This paper explores drivers for S&T agreements involving India, and how they have been used to support science diplomacy. India's decision to enter into S&T agreements with different nations is influenced by transformation of its diplomatic relationship, public interest, peacefulness of neighbourhood and in addressing global challenges. In the last decade, the number of S&T agreements of India has doubled. Indian government, diplomats and policy- makers understand deeply the urgency of boosting this sector. However, the long-term benefits to society would depend upon the ability to foster substantial scientific cooperation.

Agreements and S&T Co-operation

International agreements to promote cooperation in scientific research and development can be bilateral, multilateral, regional, government-wide or at the level of individual technical agencies. Scientific cooperation between India and other countries are undertaken using a variety of tools from informal scientist-to-scientist collaborations to cooperation between research institutions to formal agreements between implementing agencies. S&T agreements endeavour to establish a framework to foster international collaboration, protecting intellectual property, establishing benefit- sharing, and promoting networking. The text of a S&T agreement generally covers common features such as the types of cooperative activities and ways to facilitate access to facilities and personnel. There are three areas where the agreement text may vary from country to country— (1) the preamble, which is often used to highlight the public motivations behind the agreement; (2) clauses which define intellectual property rights and how the parties share and exploit the intellectual property generated; and (3) clauses related to the implementation plan, design and its review and monitoring by a joint S&T committee.

DST, the apex funding agency of Government of India, has adopted three different models to foster international relations in science & technology areas by adopting technology synergy, technology diplomacy and technology development models to achieve the above mandate. Technology Synergy model encourages parity based bilateral relationship based on mutuality, co-funding and co-creation. Technology diplomacy invests in promoting S&T base and capacity-building for developing and neighbouring countries. Technology development model is evolved to foster innovation and techno-entrepreneurship using Public Private Partnership (PPP) mode (GITA, 2019).

There are many tools used by the DST to support S&T cooperation like –(a) contact building through joint workshops, seminars, frontier symposium, exhibitions, student internships, exploratory visits or lectures by eminent scientists; (b) providing support for joint Research & Development (R&D) projects, training & advanced schools and access to advanced facilities & participation in Mega science/ consortia projects;(c) facilitation and promotion by supporting joint R&D clusters, virtual R&D networked centres & multi-institutional R&D projects and promote pre-commercial R&D and innovation through academia – industry applied & industrial R&D projects, innovation and entrepreneurship, facilitate technology development, technology transfer & joint ventures and organising annual technology summits with partner countries[3].Government of India has instituted a unique institution called Global Innovation Technology Alliance (GITA) as a Section 25 company between the Technology Development Board (TDB) and the Confederation of Indian Industry (CII) for providing demand-driven technology solutions through institutional & global alliances *via* a competitive process (AISTIC, 2019).

As part of its development co-operation, India has deployed its capabilities in space, informatics & telecommunications and in health in Africa and South Asia. India's multi-lateral co-operation in S&T also has expanded over years. This cooperation has increased with groups such as the European Union (EU), Association of Southern East Asian Nations (ASEAN), the BRICS (Brazil, Russia, India, China, South Africa), the IBSA (India, Brazil, South Africa) Foundation, the South Asian Association for Regional Cooperation (SAARC), the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC), the Asia Europe Meeting (ASEM), the East Asia Summit (EAS) and TWAS, enlarging India's influence in global arena/platforms and mainstreaming STI into its international diplomacy and foreign relations (AISTIC, 2019). India's participation and active presence in the Carnegie group, the Group of Senior Officials (GSO) on cooperation in development of Global Research infrastructures, the G20 (GRI) and the Science and Technology in Society Forum have highlighted its interest in high level policy debates, interventions, and country perspectives on the S&T issues of global significance.

Bi-Lateral and Multi-Lateral Cooperation in S&T

Ministry of Science & Technology has the responsibility to negotiate, conclude and implement S&T agreements between India and other countries in close consultation with the Ministry of External Affairs (MEA), Indian Missions Abroad, S&T counsellors, stakeholders in scientific, technological & academic institutions, concerned governmental agencies and with different industry associations in India (DST, 2019)

Presently, India has bilateral S&T cooperation agreements with 83 countries including active cooperation with 44 countries (DST, 2019). During recent years, strategic cooperation has strengthened significantly with Australia, France, Germany, Israel, Japan, Russia, South Korea, United Kingdom and the United States of America (USA). There is reciprocal cooperation with Brazil, Canada, Belgium, CIS & East European, Finland, Italy, Mexico, Norway, Netherlands, Portugal, South Africa, Switzerland and Sweden.

DST is also supporting three bi-national S&T Centres, which are independent entities established under the inter-governmental bilateral agreements with France, Germany and the USA[3]. Cooperation with African countries has also been strengthened through the India Africa S&T initiative. The soft power of S&T has been leveraged to engage with many countries under India's Act East policy and with some of the neighbouring countries (PIB, 2015).

Role and Scope of S&T Agreements

Bilateral cooperation with other nations provides access to valuable additional expertise & high-end resources; in joining hands in new areas like nano-technology, artificial intelligence, additive manufacturing, etc. and helps to avoid duplication of effort. Mutually beneficial S&T agreements result in faster progress on common goals at lower cost and provide a positive rationale for maintaining good diplomatic relations even in the face of disagreements on other issues. The following examples highlight the role of S&T agreements through existing research capacity, joint commission meetings and commitment of resources.

The United States of America (USA)

India and the USA share rich history of bilateral cooperation in scientific research and programmes[7]. During the initial days after independence, agricultural research collaboration which flourished as U.S. Public Law 480 (PL480, also known as Food for Peace) had supported the Green Revolution in India (US Library of Congress archives). Over the years, many more funding agencies and research institutions and collaborations evolved and included an increasingly large number of Indian and US technical agencies. In 1960s, a distinguished Massachusetts Institute of Technology (MIT) professor led a US delegation that worked with a group of Indian counterparts to create the Indian Institute of Technology (IIT), Kanpur (MIT, 2007). A consortium of nine US universities/institutions provided assistance to IIT, Kanpur, over a period of ten years (1962-1972) (IUSSTF, 2009). Researchers to researchers' partnerships were effective through ups and downs of diplomatic relations.

Despite major differences on issues like nuclear non-proliferation, technology restrictions and Pakistan, the Indo-US Science and Technology Forum (IUSSTF) was established under an agreement between both the governments in March 2000 during the visit of President Bill Clinton (US DoS, 2000); (IUSSTF 2002; Neureiter, Norman & Cheetham Michael, 2013). After a few years, the S&T agreement was revised into a formal framework agreement to continue co-funding of IUSSTF. This co-funded joint programme supported the interaction of more than twelve thousand US and Indian scientists over three hundred technical workshops, forty virtual joint research centres, and thirty advanced training programmes (IUSSTF, 2009)

S&T engagement between the US and India remained robust following the signing of the agreement in 2005 (IUSSTF, 2009). Subsequent joint commission meetings enabled review of implementation of the agreement and provided a forum for discussing obstacles to cooperation. Now, enthusiasm for bilateral partnership is becoming stronger and driving the process to foster S&T relationship in a way previously thwarted by sanctions and disputes over intellectual property rights.

Russia

India had a very friendly and long standing bilateral scientific cooperation with Soviet Union; which began with signing of the S&T Agreement in 1972 (DST, 2019). Subsequently, this cooperation was implemented through the Working Group on Science & Technology, the Integrated Long-Term Programme (ILTP) of cooperation in science and technology, the basic science cooperation program, the Inter-Academy exchange program, the Indo-Russian S&T centre and the Inter-Ministerial science, technology and innovation cooperation, which institutionalised bilateral level programmes and mechanisms. Scientific cooperation with Russia during 1987-90 was the biggest and most exhaustive scientific collaboration that the India had ever entered into with another country. Under this, eight joint Indo-Russian centres were established to pursue the areas where large interactive research work progressed—these were the Advanced Research Centre for Powder Metallurgy and New Materials at Hyderabad, Bharat Immunologicals and Biologicals Corporation Ltd. (BIBCOL) at Bulandshahr, the Indo-Russian Centre for Advanced Computing Research at Moscow, the Indo-Russian Centre for Biotechnology at Allahabad, the Indo-Russian Centre for Gas Hydrates Studies at Chennai, the Indo-Russian Centre for Earthquake Research at New Delhi, the Russian Indian Centre on Ayurvedic Research at Moscow and the Indo-Russian Centre for Biomedical Technology at Thiruvananthapuram. Post 1991 (CGI Russia, 2019; Embassy of India-Moscow, 2019) when the Soviet Union underwent political restructuring, Russia implemented the ILTP in place of the former Soviet Union. The initial phase of Russia being an independent, sovereign nation saw a lot of chaos, which affected its science funding and mobility of good scientists. India still continued to work with Russia in that period also, and developed programmes with several agencies promoting basic and applied research, including Russian Foundation for Basic Research, Ministry of Higher Education & Science, Russian Science Foundation, Rusnanotechnology, etc. These programmes are being presently also implemented with full vigour (PIB, 2017).

Considering mutual interest to promote innovation and technology development and individual expertise in some areas such as technology licensing, the number of scientists and engineers, and science & mathematical education levels, there is a need in future for more agreements and forward steps to exploit benefits of industrial realization of high technologies and commercialization of products developed by joint research.

France

Indo –French S&T cooperation has a long and rich history wherein strong bonds were created between Indian and French Scientists by concluding an S&T agreement on 18 July 1978 (DST, 2019). Indo-French Centre for the Promotion of Advanced Research (IFCPAR/CEFIPRA), established in 1987, is a model of bilateral R&D cooperation in advanced areas of S&T (CEFIPRA, 2019). DST and the Ministry for Europe & Foreign Affairs, Government of France, are nodal agencies to support Indo-French STI system through various activities. IFCPAR scientific collaborative research programmes focus on academia-to-academia collaborations, industry academia research &development, innovation programmes through PPP mode and dedicated mobility support programmes for young researchers to work and connect socially & culturally with partner countries (DST, 2019).

Besides the umbrella of the CEFIPRA, collaboration to develop better water technologies resulted in the 'Indo-French Cell on Water Sciences' at Bangalore (Now Bengaluru), the 'Indo-French Centre for Ground Water Research' at Hyderabad and the 'Indo-French Program for Research on Weather & Climate' at Goa. Department of Biotechnology, Govt of India signed separate MoUs with the Institut National de la Recherche Agronomique (INRA), the Centre National de la Recherche Scientifique (CNRS) and the Universite Pierre et Marie Curie (UPMC) to promote joint research in biotechnology, bioinformatics, pharmacogenomics and agrarian research. There are several Indo French Joint virtual operational labs in India and France. The signing of an agreement in January 2016 in New Delhi to establish a Joint Indo-French Science and Technology Committee showed a step forward to further enhance the existing bilateral cooperation (CEFIPRA 2019; EOI Paris, 2019)

Germany

Using science as a diplomatic tool to build people-to-people relations with India, Germany is focusing on increasing collaborations among scientists and academia of the two countries. The Inter-Governmental Agreement on Cooperation in the Field of Scientific Research and Technological Development was signed in 1974 (MEA, 2007). DST-DAAD is a Project-based personnel exchange bilateral research promotion program resulting from the Memorandum of Understanding (MoU) concluded in 1998 between the German Academic Exchange Service (DAAD) and DST. This led to more than 700 joint publications; and training of more than 2000 PhD students from both sides (Indian Embassy Berlin, 2017)

The Indo-German Science & Technology Centre (IGSTC) was established with a commitment of funding of 2 Euro million (13 Crores) per year for the first five years to facilitate Indo-German R&D networking through substantive interactions among governments, academia/research systems and industries, thus fostering innovation for overall economic and societal developments in both the countries (MEA 2007; DFG 2011). Through its flagship programme "2+2 Mode of Partnership", IGSTC intends to catalyse innovation centric R&D projects by synergising strength of research/academic institutions and public/private industries from India and Germany. Both the governments have agreed to extend the IGSTC for another five years with a doubling of funding from Euro 2 million to 4 million; starting from 2017 (IGSTC, 2019)

DST and DAAD also jointly support an Indo-German Centre on Sustainability at IIT Madras with RWTH Aachen University, TU9 and CAU, Kiel from the German side. Apart from these, India is working closely with the Federal Ministry of Education & Research (BMBF), the German Research

Foundation (DFG), the Max Planck Society, the Lindau Foundation, the International Facility for Antiproton and Ion Research (FAIR), the Deutsches Elektronen Synchrotron (DESY), the Forschungzentrum Julich GMBH (FZJ) and the Helmhotz Association to foster mobility, use of international facilities and joint collaborative research projects in different S&T areas (Indian Embassy-Berlin, 2017; DFG 2011).

Africa

India-Africa bilateral engagements were strengthened through the structured mechanism of India-Africa Forum Summit which was first held in 2008 in Delhi, followed by the second in 2011 at Addis Ababa, Ethiopia, and the third in Delhi in 2015 (DST, 2019). India played an important role in the development and implementation of engineering projects in sectors such as irrigation, electrical power and railway management in Africa. India also helped establish a residential Royal Technical College in Nairobi, in 1956 to provide technical, commercial and arts education, bearing a cost of $1.5 million. India's continuous support in field of capacity- building and training become more visible when DST and Ministry of External Affairs, through the Federation of Indian Chambers of Commerce and Industry (FICCI), launched the C. V. Raman International Fellowship program to give an opportunity to African researchers to join Indian laboratories for collaborative research (Chaturvedi, 2015).

Another example of India-Africa S&T cooperation is the Square Kilometer Array (SKA), which is a large multi radio telescope project under development in Australia, New Zealand, and South Africa (DST, 2018). It is being developed in the Southern Hemisphere with cores in South Africa and Australia, where there is least radio interference to observe the Milky Way Galaxy. The project would address some of the most interesting scientific questions in Astrophysics, ranging from characteristics of the early Universe to the search for intelligent extra-terrestrial life (PIB, 2017).

Participation in Mega Science Projects

The STI 2013 policy (DST, 2013) of India advocates its participation in mega science projects. Global mega science projects offer cross-border cooperation between teams of competent researchers within shared budget and infrastructure to address global issues like climate change, natural systems and disasters (early warning systems for tsunami, earthquakes, landslides, retro-fitting), ocean circulation & weather, nuclear arms control, health etc.

Indian Initiative in Gravitational-wave Observations (IndIGO)

IndIGO, is an initiative to set up advanced experimental facilities, with appropriate theoretical and computational support for a multi-institutional Indian national project in gravitational-wave astronomy. Since 2009, the IndIGO Consortium is involved in constructing the Indian road-map for Gravitational Wave Astronomy and a phased strategy towards Indian participation in realizing a crucial gravitational-wave observatory in the Asia-Pacific region. The current major IndIGO plans on gravitational-wave astronomy are related to the LIGO-India project. LIGO-India is a planned advanced gravitational-wave detector to be located in India, to be built and operated in collaboration with the LIGO USA and its international partners Australia, Germany and the UK. The project has recently received in-principle approval from the Indian government (DST, 2018, IndIGO, 2019).

Square Kilometer Array Project (SKA)

SKA is an international venture with twelve members to make a most powerful radio telescope and is going through detailed design for Phase – I. Construction of SKA is expected to commence in 2019 and early science is expected from 2023. India, (with participation of 16 national institutions) became an Associate Member in 2012, and a Full Member on October 5, 2015 (DST, 2018).

India is involved in several design work packages of SKA, notably the Central Signal Processing and Telescope Manager System, which would act as the nerve centre behind the functioning of the SKA observatory. The SKA project will provide the opportunity for the Indian astronomy community to showcase and share their technological and scientific capabilities on the global stage. In parallel, the National Centre for Radio Astrophysics (NCRA) is leading the development of a next-generation Monitor and Control system for the upgraded Giant Metre wave Radio Telescope (GMRT) facility aligned with the design concepts and technology platform proposed for the SKA Telescope Manger System and will act as a valuable technology demonstrator and pathfinder for the SKA (SKA, 2019).

Experiments at the Large Hadron Collider (LHC) at CERN, Geneva

The India-Compact Muon Solenoid (CMS) collaboration is the 8th largest collaboration in the CMS experiment after USA, Italy, Russia, Germany, France, CERN and U.K with presence of 43 Ph.D. Physicists among the 1407 Ph.D (DST, 2018). India became an associate member of CERN in 2017. In relation to India's involvement in this endevour, it was stated that, "the Indian Atomic Energy Commission participated in the construction of LHC and contributed to the construction of the CMS and ALICE detectors. India also contributes to the COMPASS, ISOLDE and nTOF experiments and operates two Tier-2 Centres for the LHC Computing Grid. Indian companies Crompton Greaves and Kirloskar Systems have manufactured and supplied components including magnets for construction of the 27 km circular LHC accelerator" (Balakrishnan, 2014).

The Thirty Metre Telescope (TMT) Project

India is a Founder-member country with 30 per cent contribution in 'Cash' and 70 per cent 'In-kind' in a 30-m diameter telescope at Mauna Kea in Hawaii (USA) at an estimated cost of 1.47 billion USD (Base year 2012 USD) involving an international consortium of national scientific organisations and institutions in Canada, China, India, Japan and USA. India is contributing in different scientific aspects of hardware, instrumentation and software (DST 2018), (PIB 2016) & (TMT website 2019).

International Solar Alliance (ISA)

ISA is conceived as a coalition of solar resource rich countries to address their special energy needs and will provide a platform to collaborate on addressing identified gaps through a common, agreed approach. It will not duplicate or replicate the efforts that others like the

International Renewable Energy Agency (IRENA), the Renewable Energy and Energy Efficiency Partnership (REEEP), the International Energy Agency (IEA), the Renewable Energy Policy Network for the 21st Century (REN21), United Nations bodies, bilateral organizations etc. are currently engaged in, but will establish networks and develop synergies with them and supplement their efforts in a sustainable and focused manner. It was reported that countries located in the tropical regions, i.e., between the tropics of Cancer and Capricorn and the Equator are found to be potential members of ISA, which comes to a total of 121 countries. It is due to the abundant sunlight received by these countries. However, once the ISA Charter amendment comes into force, the membership will be open for all UN members countries (Patel, 2018). France and India are the founding members of this alliance, whereas 54 other countries have signed to be members since 2015 (ISA, 2019).

Science Diplomacy in Public Interest

The Green Revolution in India, which put an end to large-scale deaths due to starvation was started with the help of the United States-based Rockefeller Foundation and was based on use of high-yielding varieties of wheat, rice, and other grains that had been developed in Mexico and in the Philippines[7]. Vaccine diplomacy and space diplomacy are other successful examples of science diplomacy. Vaccine diplomacy facilitated engagement between countries that had historically maintained tense relations, and played an important role in eradication of polio, small pox with the development of vaccines for cholera, plague& influenza (Hotez Peter 2014). The recent successful launch of the South Asian Satellite from Sriharikota onboard the Geosynchronous Satellite Launch Vehicle (GSLV) not only reiterated the technological prowess of India's space agency but was also a landmark in science diplomacy in the region. The Indian Space Program coincides with two of the three major foreign policy issues: its relations with major powers and its need for a peaceful and prosperous neighbourhood.

Science Communication and Outreach

'Science Express' jointly conceptualized and funded by DST and Max Planck Society of Germany is another innovative mega outreach programme under the wings of 'Science Diplomacy'. DST provided the train and Max Planck provided the exhibits. Science Express was launched at the Delhi Safdarjung Railway station on October 30, 2007 with the objective of arousing interest of young people in the field of S&T. Till date, this unique mobile exhibition has completed 9 phases, which include4 phases of 'Science Express', 3 phases of 'Biodiversity Special' (SEBS) and two phases of 'Climate Action Special' (SECAS). So far, it has travelled 141,800 km, and have had 455 halts, and has been visited by more than 18 million people in 1602 exhibition days, primarily composed of students and teachers (approximately 45,000 schools, 4.067 million students and 0.22 million teachers). It has thus become the largest, the longest running and the most visited mobile science exhibition with twelve entries in the Limca Book of Records with extensive media coverage (Sharma and Prasad, 2018)

Conclusion

Signing of MoU or S&T agreements provides an opportunity to publicize overall capabilities, scientific accomplishments, S&T/ education policies and a message to people of other nations about efforts to grow as an innovation-based economy. It is valuable for India to achieve foreign policy objectives in cooperation with public diplomacy and S&T. Bilateral relationships can be crucial and foster sharing of need- based technologies with nations such as the USA and Germany, who want to attract top Indian talents to their research institutions.

S&T agreements engage the diplomatic community and give proponents a means of cooperation in national priority areas like women in science & society, nanotechnology, biodiversity, disease surveillance, or renewable energy; instead of focussing on issues such as threat of terrorism, hard economic choices, or disputes over territories. Science diplomacy is not only about science, but it is a gateway to explore economic and trade linkages with other nations. Publicity of joint S&T agreements is good press for India to improve its image at global platforms. Participation in mega science projects with different countries has been used by India to arrive at common positions in negotiations and join hands with other developing countries on matters related to the nation's priorities. India's bi-lateral and multi-lateral co-operations in S&T today cover many important and, emerging fields and research projects for addressing needs in food, energy, health and sanitation, which are directly related to implementation of the Sustainable Development Goals 2030.

References

AISTIC. 2019. International Multilateral and Regional Cooperation. Last accessed on January 31st, 2019 from https://www.aistic.gov.in/ASEAN/HomePage

Balakrishnan, B. 2014. 'India Must Become Member Of CERN – OpEd'. Retrieved on January 29, 2019 from http://www.eurasiareview.com/15112014-india-must-become-member-cern-oped/

Chaturvedi, S. 2015. "Enhancing India-Africa development cooperation". Retrieved on January 31st, 2019 from https://www.brookings.edu/research/enhancing-india-africa-development-cooperation/

Consulate General of India, Vladivostok-Russia. Indo-Russia S&T Cooperation. Last accessed on January 31st, 2019 from http://www.cgivladi.gov.in/page/indo-russian-s-and-t-cooperation/

DFG. 2011. "Analysis of India's S&T Research Capabilities and International Collaborative Strength, particularly in context of Indo-German Collaboration, 2004-09". Last accessed on January 31st, 2019 from http://www.dfg.de/download/pdf/dfg_im_profil/geschaeftsstelle/dfg_praesenz_ausland/indien/2011/111103_dfg_nistads_report.pdf

DST. 2013. "Science, Technology and Innovation Policy-2013". Last accessed on January 31st, 2019 from http://www.dst.gov.in/sites/default/files/STI%20Policy%202013-English.pdf.

DST. 2015. "TWAS, India strike major accord". Last accessed on January 31st, 2019 from http://www.dst.gov.in/sites/default/files/DST-TWAS%20POC%20on%20S%26T_0.pdf

DST. 2018. "Annual Report 2017-18". Last accessed on January 31st, 2019 from http://www.dst.gov.in/about-us/annual-reports

DST. 2019. "International S&T Cooperation. Department of Science & Technology". Last accessed on January 31st, 2019 from http://www.dst.gov.in/international-st-cooperation

Embassy of India, Moscow, Russia. Science & Technology. Last accessed on January 31st, 2019 from https://indianembassy-moscow.gov.in/activities-of-s-t-wing.php

Global Innovation Technology Alliance (GITA). 2019. Last accessed on January 31st, 2019 from https://www.gita.org.in/Aboutus

Hotez, P.J. 2014. "Vaccine Diplomacy: Historical Perspectives and Future Directions". PLoS *Negl Trop Dis*. 2014 Jun; 8(6): e2808.

Indian Embassy in Berlin. 2017. Brief on Indo-German Cooperation in Science & Technology. Retrieved on January 31st, 2019 from https://indianembassyberlin.gov.in/pdf/Indo-German%20Brief-Aug%20 2017%20EOI.pdf

Indian Initiative in Gravitational-wave Observations (IndIGO). 2019. Retrieved on January 31st, 2019 from *http://www.gw-indigo.org/tiki-index.php?page*=*Welcome*

Indo-French Centre for the Promotion of Advanced Research. 2019. Retrieved on January 31st, 2019 from http://www.cefipra.org/

International Solar Alliance (ISA). Retrieved on January 31st, 2019 from http://isolaralliance.org/

IUSSTF. 2002. "First Annual Report of the Indo-US Science & Technology Forum ending March 2002". Retrieved multiple times, latest on January 31st, 2019 from https://www.iusstf.org/assets/sitesfile/image/publications/pdf/pdf_613327511.pdf

IUSSTF. 2009. "Milestones behind Miles Ahead-Connect IUSSTF Newsletter dated May 2009". Retrieved multiple times, latest on January 31st, 2019 from https://iusstf.org/assets/sitesfile/image/publications/pdf/pdf_496849675.pdf

MEA. 2007. "Memorandum of Understanding on the creation of an Indo-German Science & Technology Centre". Retrieved on January 31st, 2019 from https://www.mea.gov.in/Portal/LegalTreatiesDoc/DE07B0471.pdf

MIT. 2007. "The MIT-India Initiative". Last accessed on January 31st, 2019 from http://web.mit.edu/india/pdf/India-Prospectus-11.30.07.pdf

Norman P. Neureiter and Michael Cheetham. 2013. 'The Indo-U.S. Science and Technology Forum as a Model for Bilateral Cooperation'. Science & Diplomacy, Vol. 2, No. 4 (December).

Patel, T. 2018. How India Found Its Place in the Sun: 7 Facts About the International Solar Alliance!. Retrieved on January 23, 2019 from https://www.thebetterindia.com/160476/india-france-modi-solar-alliance-news/

PIB. 2015. "Act East Policy Press release dated December 23, 2015". Last accessed on January 31st, 2019 from http://pib.nic.in/newsite/PrintRelease.aspx?relid=133837

PIB. 2017. 'Twenty Years of Science & Technology Cooperation between India and Africa'. Retrieved on January 28, 2019 from http://pib.nic.in/newsite/PrintRelease.aspx?relid=171454

PIB. 2017. "10th Anniversary Celebrations of Indo-Russian Partnership in Science and Technology. DST concludes a MOU with FASIE to promote Indo-Russian R&D cooperation for start-ups and SME sector- Press Release dated June 21, 2017". Last accessed on January 31st, 2019 from http://pib.nic.in/newsite/PrintRelease.aspx?relid=165801

PIB.2016. "Thirty Metre Telescope- Press release dated April 27, 2016". Last accessed on January 31st, 2019 from http://pib.nic.in/newsite/mbErel.aspx?relid=142343Science & Technology. Embassy of India, Paris, France. Retrieved on January 31st, 2019 from https://www.eoiparis.gov.in/page/science-and-technology/

Science & Technology. French Embassy in New Delhi. Retrieved on January 31st, 2019 from https://in.ambafrance.org/-Science-Technology-

Sharma J. and Yarlagadda, KDV. 2018. Perspectives of 'STEM education and policies' for the development of a skilled workforce in Australia and India', International Journal of Science Education, 40:16,1999-2022, DOI: 10.1080/09500693.2018.1517239

Square Kilometer Array Project (SKA). Retrieved on January 31st 2019 from https://www.skatelescope.org/

The Indo-German Science & Technology Centre (IGSTC). Retrieved on January 31st, 2019 from https://www.igstc.org/

Thirty Meter Telescope. Retrieved on January 31st, 2019 from https://www.tmt.org/

US Department of State. 2000. History of U.S. Relations with India. Fact Sheet released by the Bureau of South Asian Affairs, U.S. Department of State, Washington, DC, August 31, 2000

US Library of Congress. "The Green Revolution". Last accessed on January 31st, 2019 from http://countrystudies.us/india/104.htm

PERSPECTIVE

Brain Drain and Brain Circulation: Why Collaboration Matters?

Nimita Pandey*

NIMITA PANDEY

Movement of science and engineering students from developing countries to the developed counterparts has been a global phenomenon, which has had implications for human resource development and utilization of knowledge capital. . This process has led to the emergence of 'brain drain'[1] (Balmer, Godwin and Gregory, 2009). However, it has been observed that scientists and technologists from the developed countries are moving to their home countries as well. This trend is evident in countries like India and China, which are catching up in advance technologies including information technology, genomics, material science and space technology, to name a few. Scholars and researchers have termed this phenomenon as 'brain circulation'[2] (Saxenian, 2005).

In India, there is a considerable movement of scientists and academics from developed countries to India, particularly those of Indian origin. Research scholars have opined that the internationalisation of scientific research (Guellec and de la Potterie, 2004), shifts in geography of innovation (Agrawal *et al*., 2011), enhancement of scientific capabilities (Davenport, 2004), recognition to S&T research as well as escalating global competitiveness are some of the factors leading to 'Brain Circulation' in India. In the early decades, Indian science fraternity witnessed the phenomenon of 'brain drain', where many science

*Research Associate, RIS.

students and engineering graduates opted to move abroad for higher studies and research. The factors that led to brain drain include lack of funding, inadequate infrastructure, absence of skill building avenues, employment opportunities and others (Beine, Docquier and Rapoport, 2001). However, with brain circulation, the scientists and engineers of Indian origin are returning back to India, to be a part of academia, industry as well as public research organizations. Interestingly, these returnees are transforming as 'nodes' of collaborations, with the global scientific community at various geographical locations. International collaborations in Indian science and engineering arena are predominantly led by such individuals or institutions, which have established some relationships with scientists in foreign countries, particularly in US and Europe. This trend has reinstated the inter-linkages between 'core' (developed, scientifically advanced) and 'periphery' (developing, scientifically catching-up), giving rise to collaborative research and innovation, technology transfers and joint projects of scientific relevance.

Various scholars have asserted that India's S&T linkages with developed countries, should strive for mutual learning and research advancements, vital for the country's socio-economic and scientific development. Recently, an article by Roli Varma and Meghna Sabharwal highlights the existing challenges and opportunities in international collaborations between India and US, based on a National Science Foundation-funded study; it involves interviews of 83 scientists and academics who have been educated and trained in the US and are now faculty in Science and Engineering(S&E) at Indian institutions. These scholars are familiar with the research culture of the US, by virtue of their training in similar scientific environment. In this context, authors have revisited the definition of 'international research collaborations' – 'as a process whereby scientists and engineers… collaborate across borders to produce scientific knowledge and applications that allow them to participate in professional relations in their birth country and the foreign country'. The study is qualitative in nature with a phenomenological approach, reflecting on the social context and complexities underlying international research collaborations. It takes into account various parameters like typology of institutions of their employment (public/private), age, gender, and professional experience as well as the kind of visas they have opted to work in India. From the interviews, the authors have detailed the structure and dynamism in formal and informal collaborations, which reap into collaborative research and joint projects. One of the peculiar findings is that these returnees are more compatible with European researchers than American contemporaries. Interestingly, the researchers were also collaborating with Southern countries. Most of these alliances were international collaborative research and student exchange as compare to joint projects on technology development and transfer.

The study highlights that the ability to collaborate is significantly dependent on time, funding, compatibility between collaborators, bureaucratic procedures as well as physical distance, and flags challenges for international collaborations, based on the aforementioned parameters. It provides recommendation in terms of increasing funding opportunities, flexible government policies, creating projects for mutual benefits and addressing issues of racial and gender discrimination. The uniqueness of the study lies in undertaking an unconventional method to analyse collaborations, which reflects on collaborations beyond joint publications. The emerging cosmopolitan characteristics of these returnees, well-captured in the article, are evident from India's growing cross-border collaborations in S&T. Reasserting the core-periphery model, the authors have mentioned that while India's scientific competencies have grown manifolds, the US is yet to give away the conventional, hierarchical and discriminatory attitudes, which are overpowering collaborative efforts and hampering scientific advancements for societal good.

However, the qualitative approach does not provide insights to international collaborations across sub-disciplines, useful in identifying research disciplines where successful collaborations exist, or say, where such alliances are yet to take place. Besides underlying the factors impacting collaborations, it would have been helpful to cite the institutional and policy landscape of both the countries, more coherently to understand the emerging trends and their relevance. Indubitably, the study holds significance for scholars and practitioners in science technology and innovation studies, policy research and science diplomacy, to reflect on the challenges and gaps in cross border collaborations, particularly between researchers from developed and developing countries. The articulate undertone of the article lays emphasis on creating indigenous S&T capabilities and developing alternatives of cooperation amid southern countries, based on need-based and action-oriented research goals.

Endnotes

1 Brain drain can be defined as the migration of skilled human capital for better standard of living, education, employment, etc. (Beine, Docquier and Rapoport, 2001). Predominantly, the migration is observed from developing countries to the developed ones (Docquier, Lohest and Marfouk, 2007).

2 Brain Circulation refers to the reverse flow of investment, trade, expertise and skills from the Diaspora or returnees to home country (-ies) (Kone and Özden, 2017). It has been considered a critical phenomenon in transforming Brain Drain to Brain Gain (Gaillard, Gaillard and Krishna, 2015).

Reference

Balmer, B., Godwin, M. and Gregory, J., 2009. The Royal Society and the 'brain drain': natural scientists meet social science. *Notes and Records of the Royal Society*, *63*(4), pp.339-353.

Agrawal, A., Kapur, D., McHale, J. and Oettl, A., 2011. Brain drain or brain bank? The impact of skilled emigration on poor-country innovation. *Journal of Urban Economics*, 69(1), pp.43-55.

Saxenian, A. 2005. From brain drain to brain circulation: Transnational communities and regional upgrading in India and China. *Studies in comparative international development*, 40(2), 35-61.

Beine, M., Docquier, F. and Rapoport, H., 2001. Brain drain and economic growth: theory and evidence. *Journal of development economics*, *64*(1), pp.275-289.

Davenport, S., 2004. Panic and panacea: brain drain and science and technology human capital policy. *Research policy*, *33*(4), pp.617-630.

Docquier, F., Lohest, O. and Marfouk, A., 2007. Brain drain in developing countries. *The World Bank Economic Review*, *21*(2), pp.193-218.

Guellec, D. and de la Potterie, B.V.P., 2004. Measuring the internationalisation of the generation of knowledge. In *Handbook of quantitative science and technology research*(pp. 645-662). Springer, Dordrecht.

Kone, Z.L. and Özden, Ç., 2017. Brain drain, gain and circulation. In *Handbook of Globalisation and Development*. Edward Elgar Publishing.

Varma, R. and Sabharwal, M., 2018. International Collaboration: Experiences of Indian Scientists and Engineers after Returning from the United States. *Perspectives on Global Development and Technology*, *17*(5-6), pp.593-613. Retrieved on January 23, 2019 from https://brill.com/view/journals/pgdt/17/5-6/article-p593_7.xml

REPORT

Technology, Innovation and Inclusive Growth: A Note on Pathways Commission's Report

Geetika Khanduja*

GEETIKA KHANDUJA

Technology-driven innovations have influenced human civilisations, nature and economies in various ways. Scientific breakthroughs and technological advancements have a pivotal role in economic development. Apart from impacting Gross Domestic Product (GDP) of a country, technology is significant in defining the future of education, healthcare, employment as well as climate change and biodiversity. However, to address societal challenges and achieve sustainable development goals, it is important to devise technology management mechanisms for inclusive development.

Amid such debates, the report *Charting Pathways for Inclusive Growth: From Paralysis to Preparation*, brought out by the Pathways Commission on Technology and Inclusive Development, examines the impact of technological innovation on growth and development of economies. The Pathways for Prosperity Commission on Technology and Inclusive Development is managed by the Oxford University's Blavatnik School of Government with collaboration of international development partners, governments, private sector leaders, emerging entrepreneurs and the civil society. It aims to catalyse new conversations about frontier technologies and also encourage co-design of country level solutions, to bring forward inclusive, accessible and affordable technologies for the marginalised sections of the society.

*Research Assistant, RIS.

The report asserts that advanced technologies need to be combined with sound policy choices, in order to discover new pathways to world prosperity. This report assumes great significance in the current discourse of advanced technologies, as Artificial Intelligence (AI) is creating ripples in the employment market. The potential disruptions caused by high-tech innovations have become a global concern, especially for the developing world; the population in such countries are predominantly dependent on manual or less automated jobs for livelihood. In the contemporary age, when new technologies are radically transforming lives around the world, this report brings in diverse perspectives to adopt a balanced approach for assessing impacts of technological innovation. The report advocates that developing countries are to be inclusive in the current digital age, and be prepared for the disruptions as well as harness opportunities created by frontier technologies. It asserts on undertaking an optimistic view towards addressing challenges of the new wave of technology, and engage in collective action for avoiding policy paralysis and unethical practices.

However, it was brought to light through the report that disruption of jobs and people's lives happen as a result of technological advancement. It can potentially drive migrations within and outside the economies, also lead to exclusion of communities, if not properly managed on a political level. Hence, Pathways Commission puts greater onus on the local conditions and policy actions for managing technological change and tapping the potential economic opportunities that it brings along.

Further, the report charts out five possible pathways for prosperity using technological innovations. It reports that the use of data analytics, communications and biotechnology in agriculture can lead to better yields, more productive crops and efficient services in agro-logistics. Similarly, manufacturing sector could benefit by the use of automation and frontier communication technologies resulting in a higher manufacturing growth. The report also mentions the use of communication technologies in the services sector has been a harbinger of new opportunities. Not only it has made international trade easier and customer-friendly with technological interfaces making possible face-to-face contact, but has also improved healthcare support, management advisory services and led to better integration in all kinds of business services. The linkages provided by the digital economy have narrowed the existing gap between the formal and the informal sector, paving way for socially-inclusive societies. Furthermore, technologies like the internet are enabling the flow of information, bringing in new ideas and leading to better networking; all fostering healthy competition among markets, facilitating complex value chain integration and beginning of an era of a global knowledge transfer regime.

For harnessing the benefits being offered by the technological innovations, the report suggests three policy priorities for the economies. Firstly, there is need to create digital-ready country by building a strong digital infrastructure as well as providing digital access. It asserts that expanding the digital capabilities would require investing in hard connectivity infrastructure as well as building on the technical skills and basic digital literacy. Secondly, a sound competition policy will aid in guiding markets towards innovation and innovation friendly business environment. This requires better access to financial services and an enabling tax regulation framework. Thirdly, the gains derived from technological advancements are to be inclusive. In this regard, focus on skill building, education, creation of balanced and inclusive job market and providing social protection to the workers assumes vital significance.

The report also highlights the importance of international cooperation in capitalising on technological progress. It brings up the dependence and inter-connectedness of domestic policies on international regulatory frameworks that govern cross-border taxation, intellectual property, trade and competition. It calls out on concerted international cooperation for bridging the resource gap existing between the developed and the developing world.

The full report can be accessed at https://pathwayscommission.bsg.ox.ac.uk/sites/default/files/2018-11/inclusive-growth-report.pdf

Science Diplomacy

Barcelona's City-led Initiative for Science and Technology Diplomacy

Science and technology has become a crucial tool in diplomacy and international affairs. This role emerges from a redefinition of global challenges such as climate change, food and water security, global health and digitalization. Scientific values of rationality, transparency and universality can promote better global governance and trust between nations and societies.

Global cities are playing an increasingly important role in STI. By 2025, the 600 largest urban economies in the world will produce 65 per cent of global economic growth. By 2050, nearly 70 per cent of the world population will be urban. Cities are innovation powerhouses, transforming the international scene and bypassing nation-states and their borders. They have become the early adopters of emerging technologies, testbeds for scientific change and becoming autonomous diplomatic players.

Barcelona has launched SciTech DiploHub, the Barcelona Science and Technology Diplomacy Hub, a non-profit, civil initiative by an interdisciplinary, international team of scientists, engineers and foreign affairs professionals committed to making Barcelona the first city in the world to implement a science and technology diplomacy strategy. The goals are:

- To consolidate Barcelona as an innovation capital, to meet the United Nations Sustainable Development Goals through science and technology.
- To position the city as an influential geopolitical actor through science diplomacy and paving the way for other global cities committed to developing their own science and technology diplomacy strategies.
- To promote a sound and inclusive multi-stakeholder dialogue to design and deploy Barcelona's science diplomacy action plan, through partnerships among the scientific community, startups, policymakers, NGOs, the diplomatic corps, the private sector and civil society.
- To empower a global network of top scientists and technology experts educated in Barcelona, the Diaspora community, to foster international cooperation, showcase our scientific strengths abroad and help us to better understand and interpret key global issues
- To become a world-class think tank where scientific expertise and innovation can be harnessed in support of an evidence-based local and foreign policy.
- Some of the on-going programmes at Barcelona's SciTechHub are as follow:
- The Barcelona SciTech Diplomatic Circle is an initiative that aims at becoming the platform to engage actively with the resident diplomatic missions.

- The Global Council an advisory body consisting of internationally acclaimed professionals educated in Barcelona
- The Open Event Series will bring stakeholders together around emerging issues of science and technology diplomacy.
- The SciTech Diaspora aims to engage with the community of scientists and engineers from Barcelona and alumni of the city ’s research centers and universities currently based abroad.

The initiatives of Barcelona city in science diplomacy may hold useful lessons for other cities especially in developing countries that have the potential to emerge as science and technology hubs. For more details, please visit http://www.scitechdiplohub.org/

Science and Technology

India's STI Cooperation in 2018: Significant Milestones

The year 2018 saw Indian Science further getting recognised in the global science and technology arena as one of the most powerful instruments for country's growth & development. The beginning of the 2018 was marked by establishment of a US$ 40 million "India-Israel Industrial R&D and technological Fund" in the month of January. The fund is aimed at extending support to joint R&D projects in order to co-develop innovative technology-driven projects. The major focus sectors identified for the project are Agriculture, Information & Communication Technology (ICT), Water, Healthcare and Energy (DST 2018).

Another major event of the year 2018 was the India-UK Science & Innovation Policy Dialogue where brainstorming discussions related to the governance challenges in the science policy domain were held. The need to scale up collaborations in various science-related fields such as artificial intelligence, digital economy, smart urbanisation, clean technologies and health interventions were acknowledged at the fora.

Around 27 Indian Scientists/Innovators were deputed by the Department of Science & Technology for participation in the 3rd BRICS Scientist Conclave which was held in Durban, South Africa during the last week of June 2018. Themes related to Energy, Water and Use of ICT for Societal applications were covered at the conference which also witnessed the announcement of the BRICS most promising Innovator being conferred to a young Indian innovator. The BRICS nations are increasingly making their strong presence felt across the world in the field of education. The nations have also started coordinating more among each other with regular student exchanges happening. Efforts are also underway for establishing a BRICS Network University. This would be an initiative that will allow universities in the countries in the grouping to develop courses together, allow common qualifications and make the process of transmission of academic credits relatively easier (Financial Express 2018).

Establishment of Indo-Korean Centre for Research and Innovation (IKCRI) in India was a major partnership between India and the Republic of Korea in July 2018. The centre will act as a hub for innovation, entrepreneurship and technology transfer between the two countries. The DST-CII Technology Summit held in New Delhi during October 29-30, 2018, with Italy as partner country was yet another important science diplomacy initiative undertaken by the Government of India. India already has a joint science institution called the Indo-Korea Science & Technology Center which was established in 2006 and is located in the city of Bengaluru. The center aims at strengthening the scientific collaboration between India and Korea by leveraging complementary strengths and expertise of the two countries (IKST 2019).

As part of its Act East Policy, the 1st ASEAN-India InnoTech Summit was hosted by India towards the end of the year. The main purpose of the summit was to exhibit and build networks between India and ASEAN researchers, innovators and technocrats. For more details, refer to the full report by DST at http://pib.nic.in/newsite/PrintRelease.aspx?relid=186493

References

DST. 2018. "Call for Proposal (CFP-2) under India-Israel Industrial R&D and Technological Innovation Fund". Retrieved on February 11, 2019 from http://www.dst.gov.in/sites/default/files/India%20-%20Israel%20I4F%20Advertisement.pdf

Financial Express. 2018. "BRICS Power for Higher Education: what grouping can achieve". Retrieved on February 11, 2019 from https://www.financialexpress.com/opinion/brics-power-for-higher-education-what-grouping-can-achieve/1329531/

IKST. 2019. "Indo-Korea Science & Technology Center website". Retrieved on February 11, 2019 from https://www.ikst.res.in/index

Health

Successful New Drug Trials for MDR-TB

A new treatment for multi-drug-resistant strain of tuberculosis can cure 80 per cent of sufferers, according to a recent trial in Belarus reported on 22 October. Of the 181 patients given the new drug, 168 people completed the course and 144 were totally cured compared to 55 per cent success rate for presently available treatments. The same rate of success was reported in trials of the drug, bedaquiline in eastern Europe, Africa and Southeast Asia. Researchers from the Republican Research and Practical Centre for Pulmonology and TB in Minsk, called the bedaquiline results "promising". Unlike many antibiotics, bedaquiline doesn't attack the bacteria directly and instead targets the enzymes that the disease relies on for its energy leading to to cell death, even in dormant or nonreplicating mycobacteria.

At present, Bedaquiline is reserved for patients with multidrug-resistant tuberculosis when no other treatment is possible. Clinical trials of Bedaquiline for the treatment of multidrug-resistant tuberculosis have been ongoing for some time. Approval for this drug has been pending due to concern over adverse effects. US FDA gave approval in December 2012, making it the first new medicine for TB in more than forty years. While the drug is available, the cost for six months is approximately $900 USD in low income countries, going up to $30,000 USD in high income countries, making it quite expensive.

Tuberculosis killed at least 1.7 million people in 2017, according to the WHO, and is responsible for the majority of HIV/AIDS deaths. Multidrug-resistant tuberculosis, immune to two of the most common antibacterial drugs (isoniazid and rifampicin) used to treat the disease is a growing problem in 117 countries around the world including India. An annual contribution of $13 billion has been pledged by UN member states recently in order to make the access to vital drugs cheaper and more accessible. Furthermore, the world leaders have also agreed to extend the research component to $2 billion. Scientists and policymakers are concerned that tuberculosis could spread through richer nations. India would be an important beneficiary of the initiative, if it succeeds, as the country accounts for one-fourth of tuberculosis cases worldwide. More affordable and effective drugs like bedaquiline could make a huge difference.

Source: Medical Express. 2018. "Game Changer Tuberculosis drug cures 9 in 10". Retrieved on February 8th, 2019 from https://medicalxpress.com/news/2018-10-drug-slashes-death-drug-resistant-tb.html

Launch of India's First Artificial Heart Valve Technology

Meril Life Sciences, a India's top medical device maker, recently launched its first indigenously designed and manufactured artificial aortic valve for patients at high risk of an open-heart valve replacement surgery. Heart valve surgery is needed to treat the heart valve disease when one of the four valves stop functioning properly. Many surgical procedures are used to replace the affected heart valves, including open-heart surgery of minimally invasive heart surgery.

The technology called Transcatheter Aortic Heart Valve Replacement (TAVR) will be sold under the brand name "Myval" and falls in line with the Make in India initiative of the government. It involves a minimally invasive procedure wherein an artificial valve is placed into the patient's diseased valve via a catheter inserted through the femoral artery. One of the salient aspects of this novel Myval technology is its association with zero new pacemaker implantation rates post-surgery. This is an important benefit for the patient already treated for valve replacement. The new treatment also offers another benefit of a faster recovery time as compared to other traditional methods and is thus becoming a preferred alternative among the valve replacement patients.

Having already received approval from the Central Drugs Standard Control Organisation for commercialization of the treatment, the company would be the first Indian company to make this surgical procedure available in the country.

Source: ICMR. 2018. "ICMR Media Report (8 to 14 December)". Retrieved on February 8^{th}, 2019 from https://www.icmr.nic.in/sites/default/files/Health_News_0.pdf

Micro-needles for Affordable Painless Injections

Researchers from IIT Kharagpur have developed micro-needles which can be used for painless delivery. Made up of carbon, these carbon needles showed no toxicity when tested on mice models. For drug delivery, the needles were arranged in a patch (10*10), which was attached to a 5 ml syringe and then the flow rate studied. The researchers found that the flow corresponds to the inlet pressure suggesting that drug delivery can be controlled by managing the pressure.

Having a length of only 400 micrometres, these needles are completely painless, as claimed by the developers. When a needle is inserted into the skin, it experiences resistance from the skin; a good needle should be able to overcome that resisting force. The team performed a number of compression and bending tests to check the strength of the newly developed product.

The team is now working on developing a drug reservoir and micro-pump to be attached to the patch for controlled drug delivery. The researchers are also working on the possibility of fabricating a dia-aid (just like a band-aid) for the diabetic patients for painless administration of insulin.

Source: Nature. 2018. "Glassy carbon micro-needles- a new transdermal drug delivery device derived from a scalable C-MEMS process". Microsystems & Nano-engineering 4 (38). Retrieved on February 8^{th}, 2019 from https://www.nature.com/articles/s41378-018-0039-9?WT.feed_name=subjects_biotechnology

Call for Contribution

Science Diplomacy Review (SDR), a multidisciplinary, peer-reviewed journal, aims to capture developments, updates and events on science diplomacy. We invite contributions from interested readers on issues related to Science Diplomacy, in theory and practice. Reviews of latest publications – research articles, essays, books, monographs, reports - are also welcome. The contributions can be sent to Managing Editor, Forum for Indian Science Diplomacy Review, Research and Information System for Developing Countries (RIS), Core 4B 4th Floor, India Habitat Centre, Lodhi Road, New Delhi 110003, India (Email: b.balakrishnan@ris.org.in; Tel. +91-11-24682177-80; Fax: +91-11-24682173/74).

For soft-copy of SDR, editorial information, contributions, feedback and comments, **email: science.diplomacy@ris.org.in and dgoffice@ris.org.in**

Guidelines for Authors

1. Submissions should contain institutional affiliation and contact details of author(s), including email address, contact number, etc. Manuscripts should be prepared in MS-Word version, using double spacing. The text of manuscripts, particularly full length articles and essays may range between 4,000- 4,500 words. Whereas, book reviews/event report shall range between 1,000-15,00 words.

2. In-text referencing should be embedded in the anthropological style, for example '(Hirschman 1961)' or '(Lakshman 1989:125)' (Note: Page numbers in the text are necessary only if the cited portion is a direct quote). Footnotes are required, as per the discussions in the paper/article.

3. Use's' in '-ise' '-isation' words; e.g., 'civilise', 'organisation'. Use British spellings rather than American spellings. Thus, 'labour' not 'labor'. Use figures (rather than word) for quantities and exact measurements including percentages (2 per cent, 3 km, 36 years old, etc.). In general descriptions, numbers below 10 should be spelt out in words. Use fuller forms for numbers and dates— for example 1980-88, pp. 200-202 and pp. 178-84. Specific dates should be cited in the form June 2, 2004. Decades and centuries may be spelt out, for example 'the eighties', 'the twentieth century', etc.

Referencing Style: References cited in the manuscript and prepared as per the ***Harvard style*** of referencing and to be appended at the end of the manuscript. They must be typed in double space, and should be arranged in alphabetical order by the surname of the first author. In case more than one work by the same author(s) is cited, then arrange them chronologically by year of publication.

Invitation to Join Mailing List

Interested readers, who wish to avail the soft-copy version of Science Diplomacy Review (SDR), may kindly send details, along with institutional affiliation to science.diplomacy@ris.org.in. Also specify if hard-copy is desired.

About FISD

As part of its ongoing research studies on Science &Technology and Innovation (STI), RIS together with the National Institute of Advanced Studies (NIAS), Bengaluru has endeavoured a major project for Science Diplomacy this year, supported by the Department of Science and Technology. The programme was launched on 7 May 2018 at New Delhi. The Forum for Indian Science Diplomacy (FISD), under the RIS–NIAS Science Diplomacy Programme, envisages harnessing science diplomacy in areas of critical importance for national development and S&T cooperation.

The key objective of the FISD is to realise the potential of Science Diplomacy by various means, including Capacity building in science diplomacy, developing networks and Science diplomacy for strategic thinking. It aims for leveraging the strengths and expertise of Indian Diaspora working in the field of S&T to help the nation meet its agenda in some select S&T sectors.

Published by:

RIS
Research and Information System
for Developing Countries
विकासशील देशों की अनुसंधान एवं सूचना प्रणाली

Core IV-B, Fourth Floor, India Habitat Centre
Lodhi Road, New Delhi-110 003, India.
Ph. 91-11-24682177-80 Fax: 91-11-24682173-74-75
Email: dgoffice@ris.org.in Website: www.ris.org.in

CONTENTS *(continued from outside front cover)*

Forum for Indian Science Diplomacy

Follow us on:

facebook /FISD-Forum-for-Indian-Science-Diplomacy

twitter @fisd19

YouTube /RISNewDelhi